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Agglomeration, Migration, and Regional Growth

A CGE Analysis for Uganda

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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Contents

List of Tables

List of Figures

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ABSTRACT

Uganda has experienced rapid economic growth and poverty reduction over the past decade but has failed to significantly improve incomes in its northern regions where prolonged conflict has hindered growth. We consider three strategies to close this regional divide: (1) develop a north-south corridor to encourage regional trade, (2) accelerate growth in the southern capital city and encourage north-south migration, and (3) improve agricultural productivity in rural areas. We examine these strategies using a regionalized computable general equilibrium model, accounting for internal migration and productivity gains from urban agglomeration effects. Simulation results indicate that a north-south corridor benefits northern households, but its benefits are limited by the small size of northern urban centers and the low productivity of northern producers. Investing in the capital city accelerates economic growth but has little effect on other regions' welfare because of the city's weak growth linkages with other regions and small migration effects. Improving agricultural productivity, however, though less effective at stimulating national economic growth, generates broad-based welfare improvements in both rural and urban areas. We therefore conclude that without significant gains in agricultural productivity in the next decade, out-migration and urban-led growth centered in Kampala will be insufficient to significantly reduce poverty in northern Uganda.

Keywords: economic growth, poverty, agricultural development, Sub-Saharan Africa, spatial economics

1. INTRODUCTION

Uganda has experienced rapid economic growth over the past decade through a combination of sound macroeconomic policies, sector reforms, public and private investments, and a boom in coffee exports. The economy grew at 6.1 percent per year during 1992–2005, driven mainly by industry and services, whose growth rates averaged 9.8 and 8.2 percent, respectively. During this period the national poverty rate declined rapidly from 55.7 to 31.1 percent. However, the agricultural sector has not performed well, with growth averaging only 2.6 percent per year (i.e., well below the population growth of 3.0 percent). Consequently, the benefits of growth have not been distributed evenly. Poverty remains concentrated in rural areas, where one in three households still falls below the poverty line compared to one in seven urban households. Moreover, the country's northern region, where a quarter of the population lives, has not participated much in the growth process. Internal conflict has undermined development efforts in a number of northern districts, leaving many inhabitants displaced. Only recently has the conflict ended and the population been able to return to their homes. As a result, the industrial core of the country has become increasingly concentrated in the more urbanized south, primarily around the capital city of Kampala. The south is also where most of the coffee exports are grown, which are an important source of foreign earnings. Consequently, while poverty in the south has more than halved since 1992, it has remained high and virtually unchanged in the north.

Persistent rural poverty and the north-south divide suggest at least three broad growth strategies for the country, each with different spatial and development implications. First, northern Uganda is geographically isolated from the growth center of the economy. Thus, one option is to invest in a transport corridor to reduce the economic distance between major urban centers in the northern and southern regions. Lowering transaction costs should open regional and international markets for northern producers. Second, the southern urban centers, especially Kampala, have demonstrated their growth potential over the past decade. A second option is, therefore, to allocate investments to reinforce the growth process in Kampala, thereby creating more employment opportunities for migrant workers. Indeed, job creation is a rising concern given the age structure of Uganda's population, which suggests that the workforce will grow at least as fast as the population over the next few decades. Third, despite urbanization, four out of five people in Uganda still live in rural areas where agriculture remains the primary income source. Accordingly, investing in smallholder agricultural productivity is another option to address rural-urban and north-south inequality.

In this paper we quantitatively examine these three investment options using a regionalized computable general equilibrium (CGE) model designed to capture the economic linkages between Uganda's northern and southern regions as well as its rural areas and major urban centers. In the next section we describe the country's regional economic structure using the database compiled for the model. In the third section we describe the model and its treatment of regional production and trade, rural-urban migration, and industrial agglomeration. The fourth section presents the model results for the three growth strategies, while the final section concludes with policy recommendations and areas for further research.

2. THE REGIONAL STRUCTURE OF UGANDA'S ECONOMY

In developing the CGE model of Uganda, we first constructed a regional social accounting matrix (SAM), which is a database that provides a complete picture of Uganda's real economy for the year 2005. The SAM draws on a wide range of data sources, including national accounts, the 2002/03 supply-use tables, government budgets, and the 2005/06 Uganda National Household Survey (UNHS3) (UBOS, 2006). We first arranged the data into a consistent accounting framework containing the incomes and expenditure flows of the government and many producers and households. However, due to different collection methods and accuracies it was necessary to reconcile the information from these data sources. Cross-entropy estimation was used to balance the SAM with as few changes to the original data as possible (see Robinson, Cattaneo, and El-Said 2001; Thurlow, Diao, and Zhu 2007). In this section we use the SAM to describe the regional structure of the Ugandan economy.

National Economic Structure

Despite agriculture's poor performance over the past decade and its declining share in national GDP, the sector remains one of the most important in the economy. In 2005, agriculture accounted for one-third of national GDP and four-fifths of total employment (see Table 1). Agricultural exports also account for two-fifths of total export earnings and two-thirds of goods exports. Coffee, tea, and tobacco are the main export crops, although the country also exports 15 percent of its food crop production. By contrast, manufacturing has grown rapidly in recent years but accounts for less than 10 percent of national GDP, half of which includes food and other agricultural processing. Most manufactured goods in the country are imported, especially capital goods. For instance, four-fifths of machinery demand in Uganda is supplied by imports. The rest of the private sector is dominated by construction and trade services, most of which are in the informal sector. Finally, the government accounts for almost 15 percent of GDP and is the largest employer of skilled labor in the country.

Table 1. National economic structure in 2005

	Share of total in 2005 (%)				Export intensity	Import intensity
	GDP share	Employment	Exports	Imports		
National GDP	100.0	100.0	100.0	100.0	8.6	17.6
Agriculture	31.1	79.3	40.3	2.9	14.5	2.2
Food crops	19.6	—	10.9	2.9	6.2	3.2
Export crops	3.0	—	21.1	0.0	81.0	0.0
Livestock	4.3	—	0.3	0.0	0.8	0.0
Other agriculture	4.2	—	8.0	0.0	20.3	0.0
Manufacturing	8.5	1.5	28.7	79.0	9.7	41.2
Food processing	4.1	0.9	16.4	7.7	9.1	9.3
Textiles/ clothing	0.6	0.2	3.4	3.8	16.6	35.5
Wood/ furniture	0.2	0.0	0.1	1.2	2.3	39.1
Chemicals	0.9	0.1	1.5	21.9	4.6	65.7
Machinery	0.8	0.1	5.6	36.3	21.3	79.5
Other manufacture	2.2	0.3	7.3	43.9	14.6	69.6
Other industry	15.5	4.3	2.7	0.8	6.0	4.3
Mining	0.5	0.3	1.0	0.8	16.2	27.2
Utilities	1.5	0.2	1.7	0.0	16.5	0.0
Construction	13.5	3.7	0.0	0.0	0.0	0.0
Private services	44.9	15.0	28.3	17.4	10.0	11.3
Trade	11.4	6.4	0.0	0.0	0.0	0.0
Other services	19.5	5.8	28.3	17.4	24.8	27.5
Public services	14.1	2.8	0.0	0.0	0.0	0.0

Source: 2005 Uganda social accounting matrix.

Note: Employment excludes unpaid family members. "Export intensity" is the share of domestic production that is exported, and "import intensity" is the share of domestic demand supplied by imports.

Identifying North-South Regions and Major Urban Centers

Rapid growth and poverty reduction have not taken place throughout Uganda. The northern region has experienced far more modest poverty reduction since 1992 (the earliest year for which we have poverty data) and has stagnated since the end of the 1990s (see Table 2). To capture regional linkages and the spatial impacts of alternative growth strategies, we disaggregated the national economy into five subnational regions. We first divided the country into north and south, where the latter comprises three of Uganda's administrative regions: Central, Eastern, and Western (see Figure 1). We then used the 2002 population census (UBOS, 2002) to identify major urban centers with populations exceeding 50,000 people.[1] This includes the capital city, Kampala, which has a population of 1.7 million people out of Uganda's total population of 27 million in 2005. Given that Kampala is the core of Uganda's industrial economy, we treat it as a separate region in the model. In the northern region there are two major cities (Gulu and Lira), which are the second and third largest cities in Uganda with a combined population of 200,000 people. The remaining urban centers lie in the southern region and have a total population of 524,000 people. Therefore, the five regions in the model are (1) northern rural, (2) northern urban, (3) southern rural, (4) southern urban, and (5) the Kampala metropolitan area. Currently a major transport route connects the southern urban centers with Kampala and with foreign markets via Kenya. Later we will model an improved transport corridor connecting Gulu and Lira to the southern urban centers via Mbale.

Table 2. Poverty trends, 1992/93–2005/06

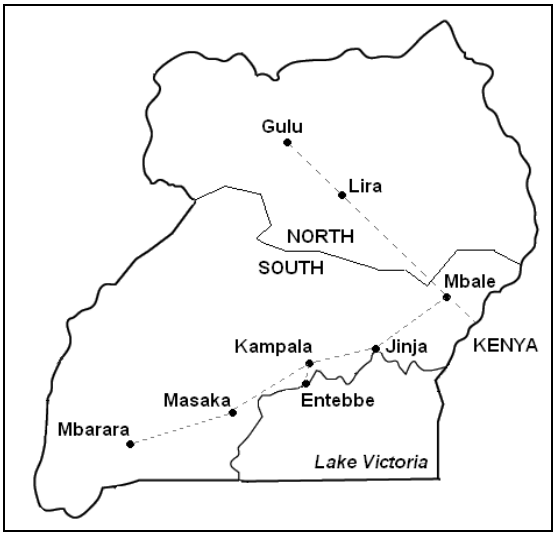
	Population share in 2005	National poverty headcount (%)			
		1992/93	1999/00	2002/03	2005/06
National	100.0	55.7	33.8	37.7	31.1
Rural	84.7	59.7	37.4	41.7	34.3
Urban	15.4	27.8	9.6	12.2	13.8
Central	29.2	45.6	19.7	22.3	14.8
Eastern	25.2	58.8	35.0	46.0	36.5
Northern	19.7	72.2	63.6	63.3	60.8
Western	25.9	53.1	26.2	31.4	21.7

Source: Okidi et al. (2005) and UBOS (2006).

Note: The population and poverty estimates are based on the definition of urban areas used in the Uganda National Household Survey, which includes many small towns and municipal areas. The computable general equilibrium model and subsequent tables define urban areas as those centers containing more than 50,000 people.

[1] The following are the cities in Uganda with populations over 50,000 (in descending order): Kampala, Gulu, Lira, Jinja, Mbale, Mbarara, Masaka, Entebbe, Kasese, and Jinja/Njeru.

Figure 1. Regions and major urban centers in the Uganda model



Regional Characteristics and Linkages

Using the 2005/06 UNHS3 and the 2003 industrial census, we disaggregated production and employment across the five regions in the model for each of the 47 sectors in the Uganda SAM (see Table A1 in Appendix A). The regional SAM indicates that while the northern regions contain 22.7 percent of Uganda's total population, they account for only 11.0 percent of national GDP (see Table 3). As such, per capita GDP is low in this region at US$150 per year compared to the national average of US$310. Most of the northern region lies in rural areas, with the two urban centers of Gulu and Lira accounting for only 0.5 percent of national GDP. Consequently, the north is dominated by agriculture, which accounts for almost half of its rural economy. This share is higher if the region's electricity and mining sectors are excluded. The northern region is a net exporter of agricultural goods, such as cotton and forestry products, as well as certain large formal-sector commodities, such as mining and electricity.

The southern region is substantially larger and accounts for 71.2 percent of the total economy. Unlike the northern region, there is a sharp divide between rural and urban areas in the south. The rural population is large and generates a similarly large share of national GDP. As such, per capita GDP is close to the national average at US$271 and is almost twice as high as in the northern region. However, average per capita GDP in the southern urban centers is US$1,074, reflecting the region's large share of higher-earning sectors, such as formal-sector manufacturing and private services. The government sector is also large due to the inclusion of Entebbe and a number of administrative capitals in this region. The southern region is a net exporter of numerous agricultural products, including maize, horticulture, coffee, and livestock. Many of the rural area's agricultural outputs are supplied to southern urban centers for further processing, such as maize for grain milling and animal feed, which are then exported to other regions.

Kampala forms the economic core of Uganda's economy. Although the region contains only 6.1 percent of the population, it generates 21.6 percent of the country's GDP. Most of Uganda's manufacturing sector is based in the capital city, especially formal-sector production. However, it is private services, such as hotels, banking, and finance, that make up more than half of Kampala's economy. Average per capita GDP in the capital is similar to other southern urban centers at US$1,098 per year. Kampala is a net exporter of processed foods and traded private services, such as finance and banking. Both Kampala and the southern urban centers are net "exporters" of government services to the rest of the country.

Table 3. Regional economic structure in 2005

	Share of region's total GDP (%)						Share of total (%)					
	North		South				North		South			
	Rural	Urban	Rural	Urban	Kampala Metro	Uganda	Rural	Urban	Rural	Urban	Kampala Metro	Uganda
Population							22.0	0.7	69.2	1.9	6.1	100.0
Regional GDP	100.0	100.0	100.0	100.0	100.0	100.0	10.5	0.5	60.7	6.7	21.6	100.0
Agriculture	47.6	3.5	42.7	1.9	0.1	31.1	16.1	0.1	83.4	0.4	0.1	100.0
Food crops	22.9	0.0	28.3	0.0	0.0	19.6	12.3	0.0	87.7	0.0	0.0	100.0
Export crops	6.2	0.0	3.8	0.0	0.0	3.0	21.8	0.0	78.2	0.0	0.0	100.0
Livestock	9.5	3.5	5.3	0.9	0.1	4.3	22.8	0.4	74.6	1.4	0.7	100.0
Other agriculture	9.1	0.0	5.2	1.0	0.0	4.2	22.7	0.0	75.8	1.5	0.0	100.0
Manufacturing	2.6	13.5	3.4	16.1	23.0	8.5	3.2	0.8	24.6	12.7	58.7	100.0
Food processing	1.5	7.7	1.9	9.5	10.0	4.1	3.8	1.0	27.9	15.4	51.9	100.0
Textiles/clothing	0.6	2.6	0.2	0.7	1.9	0.6	10.2	2.1	16.6	7.9	63.2	100.0
Wood/furniture	0.0	0.2	0.0	0.2	0.8	0.2	0.5	0.5	7.7	5.4	85.9	100.0
Chemicals	0.0	0.0	0.0	0.7	3.8	0.9	0.0	0.0	3.3	5.5	91.2	100.0
Machinery	0.2	1.8	0.2	1.2	2.9	0.8	2.0	1.1	12.5	9.4	74.9	100.0
Other manufactures	0.3	1.2	1.1	3.7	3.7	1.8	1.5	0.4	38.3	14.2	45.6	100.0
Other industry	18.5	17.8	15.0	18.0	14.6	15.5	12.5	0.6	58.8	7.8	20.3	100.0
Mining	3.0	0.0	0.3	0.3	0.0	0.5	57.5	0.0	38.6	3.9	0.0	100.0
Construction	8.8	17.8	13.9	16.4	13.6	13.5	6.8	0.7	62.6	8.2	21.7	100.0
Utilities	6.7	0.0	0.7	1.3	1.0	1.5	48.5	0.0	30.8	6.0	14.6	100.0
Private services	19.9	39.1	23.3	36.2	55.2	30.8	6.8	0.7	46.0	7.9	38.7	100.0
Trade	7.8	13.0	7.3	16.3	22.9	11.4	7.2	0.6	38.9	9.6	43.6	100.0
Other services	12.1	26.1	16.1	19.9	32.3	19.5	6.5	0.7	50.1	6.9	35.8	100.0
Public services	11.4	26.0	15.5	27.9	7.0	14.1	8.5	1.0	66.6	13.2	10.7	100.0

Source: 2005 Uganda social accounting matrix.

3. MODELING REGIONAL GROWTH AND INVESTMENTS

To assess the growth and distributional impacts of alternative investment options we developed a regional CGE model of Uganda.[2] The model is recursive dynamic and is run over the period 2005–2015. This means that the model is solved as a series of equilibriums with economic actors optimizing their behavior within each period (i.e., there is no intertemporal or long-run optimization). Given this assumption of adaptive expectations, the model can be separated into a within-period component, in which producers and consumers maximize profits and utility, and a between-periods component, when the model is updated to reflect changes in the population and labor force, capital and technology accumulation, and agglomeration economies.

The model is initially calibrated to the 2005 regional Uganda SAM, which provides information about demand and production for 47 detailed sectors in each of the five regions identified in the previous section. Based on this SAM, the production technologies in each sector and region are calibrated to their current situation (i.e., 2005), including producers' use of primary inputs such as land, labor, and capital, and intermediate inputs. To capture differences in labor markets, the model classifies employed labor into three occupation-based skill categories: skilled (e.g., managers and professionals), semiskilled (e.g., technicians and traders), and unskilled workers (e.g., farmers and laborers). Skilled and semiskilled workers are assumed to be fully employed with flexible nominal wages. By contrast, rural unskilled labor has an upward-sloping labor supply curve to capture underemployment and incentives from rising wages.[3] Information on both paid and unpaid employment and on wages by sector and region was taken from the 2005/06 UNHS3.

Within each period workers in the model can migrate across sectors within each region, but between periods they can migrate across regions in response to wage differentials. As with labor, capital can also move freely across sectors within a region. The model differentiates between formal and informal capital.[4] Between periods we capture the accumulation of capital, which depends on previous period investments financed by domestic savings and foreign inflows. New capital stocks are allocated across regions (and formal/informal sectors) according to current profit rate differentials, such that regions whose capital is earning above-average profits receive a larger share of new capital stocks. The third and final factor in the model, agricultural land, is immobile across regions but is endogenously allocated across crops to maximize returns.

An important factor determining a sector's contribution to economic growth is its linkages with other sectors in its own and other regions. The model captures production linkages by explicitly defining a set of nested constant elasticity of substitution production functions allowing producers in each region to generate demand for both factors and intermediates. The model also captures forward and backward production linkages between sectors. However, while we include differences in regional production patterns, we assume that there is a national commodity market for traded commodities in Uganda. This is equivalent to assuming that producers in each region supply their products to a central market and that a national price adjusts to equate demand and supply at the national rather than the regional level. We do, however, capture region-specific transaction costs (i.e., trade price margins) incurred when supplying goods to the market. The size of these regional transaction costs is determined by whether a region is originally a deficit or surplus producer of a commodity. Finally, we allow regional markets for certain nontraded commodities, such as construction and trade services. For these commodities there is a unique regional price that equates regional demand and supply. Foreign import competition and export

[2] The model is a regionalized version of the national model in Thurlow et al. (2008). It is also a recursive dynamic version of the IFPRI static model (see Thurlow 2003 and Appendices A and B for further details).

[3] We use a supply elasticity of 2.0 and then conduct sensitivity analysis with values of 0.5 and 4.0 (see Appendix C).

[4] Based on the industrial census and household survey, we assume that lower-skilled workers in their own enterprises or small businesses with fewer than 10 employees are in the informal sector. For lack of information on formal-sector industries, we assume similar production and employment patterns between formal and informal businesses within each industrial or service activity. However, formal capital, which is fully mobile across the economy, pays taxes, and its returns accrue mainly to higher-income urban households.

opportunities are modeled by allowing national-level production and consumption to shift between domestic and foreign markets depending on the relative prices of imports, exports, and domestic goods. More specifically, the decision to supply domestic or foreign markets is governed by a constant elasticity of transformation function, while substitution possibilities exist between imports and domestically supplied goods under a constant elasticity of substitution Armington specification.

Incomes from production, trade, and employment accrue to different households according to employment and wage data from UNHS3. Households in the model are disaggregated across the five regions and farm/nonfarm and poor/nonpoor groups. Within the southern rural region we further separated farm households into coffee/non–coffee producers. Differences in household income and expenditure patterns are important for capturing distributional change, since incomes generated in different sectors will accrue to different households depending on their location and factor endowments. Households in the model receive income through the employment of their factors of production, and then pay taxes, save, and make transfers to other households. Disposable income is then allocated to commodity consumption based on a Stone-Geary utility function (i.e., a linear expenditure system of demand).

The model makes a number of assumptions about how the economy maintains macroeconomic balance (i.e., closure rules). For the current account, a flexible exchange rate maintains a fixed level of foreign savings. This means that the government cannot increase foreign debt to pay for new investments and that export earnings are needed to pay for any additional imports. For the government account, tax rates are fixed, and recurrent expenditure grows at a fixed rate. The fiscal deficit therefore adjusts to ensure that public expenditures equal receipts. Investment and private consumption are also fixed shares of absorption, with private savings adjusting to ensure that savings equals investment in equilibrium.

Finally, two factors determine each region's annual total factor productivity (TFP) growth rate. The first is an initial TFP growth rate, which is determined exogenously in order for the model to match Uganda's recent growth trends after accounting for changes in total factor supplies. The second factor takes into account agglomeration effects caused by changes in the density of economic activity within a particular region. Following Henderson and Wang (2005), we assume that agglomeration spillovers are a function of a region's population density. Combined with the model's treatment of internal migration, this simple specification implies that a region's TFP growth rate accelerates if it is the net recipient of migrant workers (i.e., if its population expands faster than its initial growth rate). Given the sparse population of rural areas and the concentration of industry in urban areas, we allow agglomeration effects to take place only in the three urban regions in the model.

In summary, the CGE model incorporates regional growth linkages and distributional change by (1) disaggregating production patterns and technology across sectors and regions, (2) allowing interregional labor migration and agglomeration effects, (3) capturing region-specific transaction costs and specifying regional markets for nontraded commodities, (4) capturing income effects through regional factor markets and price effects through national commodity markets, and (5) translating these two effects onto different households in each region according to their factor endowment and income and expenditure patterns. This allows the model to capture the regional growth and distributional effects associated with alternative investment scenarios.

4. MODEL SIMULATIONS

The model is used to examine the regional economic growth and poverty impacts of three growth scenarios: (1) investing in a transport corridor to connect the main urban centers in the northern and southern regions, (2) accelerating growth in Kampala, and (3) improving agricultural productivity in rural areas. However, it is first necessary to construct a baseline scenario, which provides a counterfactual to which the alternative growth scenarios can be compared.

Baseline Scenario

The baseline provides a counterfactual for other simulations and is calibrated to track growth and demographic trends in Uganda. Specifically, we assign initial growth rates for population and labor supply, migration, and total factor productivity based on the period 1992–2005.

First, we assume a growth in Uganda's total population of 3 percent per year during 2005–2015. We also assume a growth in the total supply of skilled, semiskilled, and unskilled labor of 3 percent per year, which means that the national dependency ratio remains constant over time. Although we initially assign the same labor supply growth rates in all regions, over time these diverge as workers migrate between regions. Thus, while the total population and workforce growth rate is fixed, the model endogenously reallocates labor and populations between regions.

Second, for migration, we assume that current regional wage differentials generate the levels of internal migration observed in Uganda's 2002 population census. This implies a net annual inflow of approximately 26,000 migrants into Kampala, which is equivalent to 2.9 percent of Kampala's labor force.[5] Most of the workers who migrate to the capital city come from rural areas, with 62 percent coming from the south and 23 percent from the north. The remaining migrants come from smaller urban centers, with 5 percent coming from Gulu and Lira, and 10 percent from the southern cities. Migration from rural to smaller urban centers is considerably lower than to Kampala, accounting for only 0.2 percent of either the northern or southern urban centers' workforce each year. These small migration flows are insufficient to offset the larger flows toward Kampala, such that all regions experience a net outflow of migrants. In the model we initially calibrate migration flows to capture these observed migration flows and then let annual migration rates adjust to reflect changes in relative regional wages.[6] As mentioned earlier, inward migration will cause population growth in Kampala to exceed the population growth rates of other regions. Given our specification of urban agglomeration effects, this inward migration will also accelerate TFP growth in Kampala.

Finally, given the concentration of recent growth, we assume that initial TFP growth is higher in Kampala and the southern urban centers. Furthermore, given agriculture's poor performance since the early 1990s, we assume that agricultural productivity growth is declining. As shown in Table 4, nonagriculture's TFP growth rate in Kampala in the baseline scenario is initially 3.0 percent compared to 2.0 percent in smaller urban centers. By contrast, nonagriculture's TFP growth rate in the two rural regions is 1.25 percent per year, and agriculture's TFP growth in all regions is negative. This reflects the stagnation of income levels and poverty in the rural areas and northern region during the past decade.

[5] The 2002 population census asked individuals whether they had moved to the region during the previous five years (see Table A1.5 in UBOS 2006). The census reported that 11.7 percent of Kampala's population (or 140,000 people) were "recent" migrants, implying an average *annual* inflow of approximately 2.4 percent (or 28,000 people). Our initial migration rate is slightly higher due to differences between UNHS3 and the 2002 population census.

[6] The migration rate in year *t* (from region 1 to region 2) is equal to the initial migration rate multiplied by the regional wage differential (normalized to remove the initial wage differential):

$$mr^{t}_{r1r2} = mr^{0}_{r1r2} \times \left(\frac{w^{t}_{r2} / w^{0}_{r2}}{w^{t}_{r1} / w^{0}_{r1}} \right)^{\kappa}$$

Table 4. Baseline and investment scenarios

Scenario	Assumption	Northern (rural)	Northern (urban)	Southern (rural)	Southern (urban)	Kampala (metro)
Baseline	TFP growth (%)					
	Agriculture	–1.00	–1.00	–1.00	–1.00	–1.00
	Trade services	1.25	2.00	1.25	2.00	3.00
	Other sectors	1.25	1.50	1.25	2.00	3.00
Corridor	TFP growth					
	Agriculture	—	+3.50	—	—	—
	Trade services	+5.75	+11.00	—	—	—
	Other sectors	—	+3.50	—	—	—
Kampala	TFP growth					
	Agriculture	—	—	—	—	+1.50
	Trade services	—	—	—	—	+1.50
	Other sectors	—	—	—	—	+1.50
Agriculture	TFP growth					
	Agriculture	+1.50	+1.50	+1.50	+1.50	+1.50
	Trade services	—	—	—	—	—
	Other sectors	—	—	—	—	—

Note: Total factor productivity (TFP) growth rates are exogenous changes in annual growth rates applied to the model. Final TFP growth is determined endogenously within the model according to migration flows and agglomeration effects.

Table 5. National sectoral growth results

	Initial GDP share (%)	Average annual GDP growth rate, 2005–2015 (%)			
			Point deviation from baseline		
		Baseline scenario	Corridor scenario	Kampala scenario	Agriculture scenario
National GDP	100.0	6.11	0.06	0.67	0.60
Agriculture	31.1	3.44	0.05	0.13	1.25
Food crops	19.6	3.27	0.06	0.16	1.30
Export crops	3.0	2.09	0.02	–0.19	1.85
Livestock	4.3	4.23	0.05	0.34	1.40
Other agriculture	4.2	4.23	0.03	–0.07	0.47
Manufacturing	8.5	7.90	0.12	0.93	0.34
Food processing	4.1	5.48	0.07	0.58	1.08
Textiles/clothing	0.6	8.29	0.71	1.28	0.44
Wood/furniture	0.2	8.18	0.12	0.55	0.36
Chemicals	0.9	9.51	0.07	1.55	0.55
Machinery	0.8	12.99	0.17	1.63	–1.28
Other manufacturing	2.2	10.78	0.08	1.09	–0.74
Other industry	15.5	7.11	0.01	0.27	–0.16
Mining	0.5	3.69	0.36	–0.49	–0.04
Construction	1.5	8.34	0.03	1.80	0.29
Utilities	13.5	7.09	0.00	0.10	–0.22
Private services	30.8	7.45	0.04	0.91	0.27
Trade	11.4	6.83	0.15	0.82	0.51
Other services	19.5	7.80	–0.01	0.96	0.14
Public services	14.1	5.93	0.13	1.26	1.28

Source: Results from the Uganda regional computable general equilibrium model.

Given the above assumptions, Uganda's economy grows at 6.1 percent per year during 2005–2015 under the baseline scenario (see Table 5). This is driven by industry and private services, which grow at approximately 7.5 percent per year. Due to its slower productivity growth, agriculture grows below the national average at 3.4 percent. Government recurrent spending grows at a fixed rate of 5.9 percent per year, thus maintaining a roughly constant share of national GDP.

Slower agricultural growth affects food processing, whose production depends on domestically produced agricultural inputs. Nonfood manufacturing therefore drives overall manufacturing growth in the baseline scenario. These heavier manufacturing sectors are more capital intensive and generate demand for investment goods, such as machinery and construction. Accordingly, investment demand and nonagricultural imports both grow faster than national GDP, and capital stocks grow faster than other factors under the baseline scenario (see Table 6). Slow agricultural and rural nonfarm growth also causes lower real consumption growth for rural households, for whom agricultural incomes are particularly important. Real consumption spending is also offset by rising real food prices caused by slower agricultural growth.

Table 6. Macroeconomic results

	Initial share	Baseline scenario	Corridor scenario	Kampala scenario	Agriculture scenario
		Average annual growth rate, 2005–2015 (%)			
			Point deviation from baseline		
Population	30,508	3.00	0.00	0.00	0.00
GDP at market prices	100.0	6.00	0.06	0.56	0.64
Consumption	75.3	5.53	0.07	0.63	0.86
Rural	53.0	4.69	0.09	0.36	0.91
Urban	22.3	7.30	0.03	1.14	0.77
Investment	22.6	7.16	–0.02	–0.04	–0.41
Government	14.4	6.00	0.15	1.50	1.50
Exports	14.1	7.26	0.00	0.53	–0.01
Agriculture	5.7	0.40	–0.04	–0.59	2.15
Nonagriculture	8.4	10.33	0.01	0.84	–0.72
Imports	–26.5	6.44	0.04	0.72	0.42
Agriculture	0.8	9.21	0.13	1.23	–0.67
Nonagriculture	25.7	6.34	0.04	0.70	0.46
GDP at factor cost	100.0	6.11	0.06	0.67	0.60
Labor	40.0	4.09	0.12	0.51	0.92
Skilled	15.6	3.00	0.00	0.00	0.00
Semiskilled	11.8	3.00	0.00	0.00	0.00
Unskilled	12.6	4.48	0.16	0.68	1.21
Capital	41.5	5.91	–0.01	0.00	–0.12
Land	18.4	2.00	0.00	0.00	0.00
Productivity (TFP)		1.64	0.03	0.36	0.30
		Final year value, 2015			
Consumer price index	1.000	1.035	1.037	1.029	1.017
Food price index	1.000	1.157	1.160	1.161	1.084
Real exchange rate	1.000	0.984	0.986	0.953	1.000

Source: Results from the Uganda regional computable general equilibrium model.

Note: Exchange rate index is foreign currency units per local currency unit (i.e., a decline is an appreciation).

GDP growth is unevenly distributed across regions. For instance, while Kampala's economy grows at 10.4 percent per year, the northern regions grow only a third as fast (see Table 7). This causes the returns to labor to diverge across regions. Stronger industrial growth in Kampala widens the regional wage gap, causing 24,800 workers to migrate to Kampala during 2005–2015.[7] This is equal to 2.9 percent of Kampala's total workforce, which rises from 481,000 to 910,000 during 2005–2015. As such, while Kampala's existing labor grows at 3 percent per year, it accelerates faster due to in-migration, eventually averaging 6.5 percent under the baseline scenario. Growth in the labor force in the rural regions is also above 3 percent per year due to increased supply of unskilled labor, which is sufficient to offset out-migration of higher-skilled workers to southern urban centers. Although migrant workers come from both northern and southern regions, northern out-migration is more significant because of this region's smaller population and workforce. However, out-migration does not outweigh population growth in the north, and there are still rising population densities in northern urban centers. This causes positive agglomeration effects, which stimulate faster TFP growth. However, these agglomeration effects are small relative to exogenously imposed TFP growth, even in Kampala, where there is both population growth and large inward migration. Here agglomeration effects amount to 0.5 percent of the average annual TFP growth rate of 4.3 percent (i.e., 12 percent of productivity growth).

Table 7. Migration and agglomeration effects in the baseline scenario

	Uganda	Northern (rural)	Northern (urban)	Southern (rural)	Southern (urban)	Kampala (metro)
Regional GDP growth (%)	6.11	3.29	3.74	4.64	5.82	10.44
Labor employment growth	4.09	4.11	1.22	3.90	1.92	6.54
Skilled	3.00	1.87	1.27	2.38	2.51	6.12
Semiskilled	3.00	1.89	0.30	2.03	1.62	6.73
Unskilled	4.48	4.66	2.10	4.38	2.13	6.26
Capital accumulation rate	5.91	5.07	6.96	5.73	5.05	6.45
Land expansion rate	2.00	2.00	0.00	2.00	0.00	0.00
Productivity (TFP) growth	1.64	–0.16	1.96	0.83	1.92	4.27
Due to agglomeration	—	—	0.10	—	0.16	0.52
Annual migration inflows (workers)	0	–5,916	–892	–15,963	–2,006	24,776
Migrant share of labor force (%)	0	–0.28	–1.87	–0.24	–1.08	2.90

Source: Results from the Uganda regional computable general equilibrium model.

In summary, the baseline scenario is broadly consistent with Uganda's recent growth path. The economy becomes increasingly concentrated within the southern urban centers, especially within Kampala. Urban households are thus the primary beneficiaries of this industry-focused growth process. While rural households also benefit from overall economic growth, agriculture's poor performance causes their real consumption spending to dip below the national average. There is therefore both rising rural-urban and north-south inequality in the baseline scenario. Within this context, we next assess the impacts of the three investment scenarios.

Scenario 1: Connecting the Northern Urban Centers with Kampala

In the first growth scenario we simulate improvements to the transport corridor connecting the southern urban centers with the two major cities in the north (see Figure 1). We capture this investment through two adjustments to the model. First, each producer in the northern region has a trade margin that reflects whether the region is a net exporter of a particular commodity as well as the cost of supplying goods to

[7] Table 13 shows rural-urban and north-south wage differentials and migration rates, which are discussed in more detail later in the paper.

the south of the country. These trade margins generate demand for regionally produced trade services. In the corridor scenario we assume that the transport corridor will increase the productivity of northern traders. We therefore substantially increase the TFP growth rate in the northern urban centers' trade sector (see Table 4). This lowers the price of northern trade services and reduces the transaction cost incurred by northern producers when trading in the national market. We also assume that traders in the surrounding rural areas will benefit from the transport corridor, albeit to a lesser extent. Second, we assume that overall productivity will rise because of the corridor. We increase TFP growth by an additional 3.5 percent a year in the nonagricultural sectors in the northern urban centers.

Table 8. Regional sectoral growth results

	Initial GDP share (%)	Average annual GDP growth rate, 2005–2015 (%)			
			Point deviation from baseline		
		Baseline scenario	Corridor scenario	Kampala scenario	Agriculture scenario
National GDP		6.11	0.06	0.67	0.60
Northern (rural) GDP	100.0	3.29	0.74	–0.18	0.93
Agriculture	47.6	3.24	0.45	0.12	1.29
Manufacturing	2.6	–0.20	6.88	–2.53	0.70
Other industry	18.5	3.93	0.13	–1.14	–0.14
Trade	7.8	2.15	3.70	–0.59	0.89
Other services	12.1	1.26	0.23	–1.15	0.72
Public services	11.4	5.55	0.07	1.20	1.29
Northern (urban) GDP	100.0	3.74	7.60	–0.42	0.43
Agriculture	3.5	3.01	7.95	–1.26	–0.31
Manufacturing	13.5	0.51	15.32	–2.48	0.14
Other industry	17.8	6.80	0.75	–0.02	–0.26
Trade	13.0	0.22	17.99	–2.83	0.06
Other services	26.1	2.48	7.58	–1.12	0.34
Public services	26.0	5.47	1.14	1.10	1.26
Southern (rural) GDP	100.0	4.64	–0.02	–0.11	0.85
Agriculture	42.7	3.46	–0.04	0.12	1.25
Manufacturing	3.4	4.18	–0.14	–1.91	0.72
Other industry	15.0	6.87	–0.01	–0.21	–0.19
Trade	7.3	3.78	–0.20	–0.60	1.02
Other services	16.1	4.58	–0.03	–1.58	0.44
Public services	15.5	5.86	0.12	1.20	1.28
Southern (urban) GDP	100.0	5.82	–0.01	–0.53	0.33
Agriculture	1.9	5.55	0.02	0.08	–0.68
Manufacturing	16.1	4.71	–0.11	–1.99	0.26
Other industry	18.0	6.97	0.00	–0.36	–0.20
Trade	16.3	4.82	–0.11	–1.58	0.20
Other services	19.9	6.19	–0.06	–1.68	–0.27
Public services	27.9	5.95	0.13	1.23	1.26
Kampala (metro) GDP	100.0	10.44	–0.13	2.33	0.14
Agriculture	0.1	8.91	–0.09	4.59	–0.25
Manufacturing	23.0	10.04	–0.19	1.99	0.24
Other industry	14.6	9.37	–0.01	1.99	–0.08
Trade	22.9	9.92	–0.25	1.94	0.25
Other services	32.3	12.14	–0.11	2.96	–0.09
Public services	7.0	6.63	0.12	1.72	1.31

Source: Results from the Uganda regional computable general equilibrium model.

Increasing trade-sector productivity causes substantial growth in the northern urban trade sector. The sector's annual GDP growth rate increases from a stagnant 0.2 percent under the baseline scenario to 18.0 percent in the corridor scenario (see Table 8). A similar, albeit smaller, growth acceleration takes place in northern rural areas. Consequently, the price of trade services falls by between a quarter and a half in the northern regions. This benefits the north's manufacturing sector, whose products are already traded with the south, but whose market opportunities improve dramatically. Rural nonfarm activities, primarily food processing, also benefit from lower transaction costs. Although agricultural growth in northern rural areas increases, this effect remains small because productivity growth remains low. Overall, the GDP growth rate in the northern urban region doubles from 3.7 percent to 7.6 percent under the corridor scenario. While the northern rural areas also experience faster GDP growth, this acceleration is much smaller because agriculture, which is a large part of the rural economy, remains stagnant.

Table 9. Regional productivity growth and agglomeration effects

	Baseline scenario	Corridor Scenario	Kampala scenario	Agriculture scenario
	Average annual employment growth rate, 2005–2015 (%)			
		Point deviation from baseline		
Northern (rural) GDP growth	3.29	0.74	–0.18	0.93
Labor employment	4.11	0.41	0.39	0.78
Capital accumulation	5.07	0.68	–0.54	–0.24
Land expansion	2.00	0.00	0.00	0.00
Productivity (TFP) growth	–0.16	0.58	–0.21	0.76
Agglomeration	0.00	0.00	0.00	0.00
Northern (urban) GDP growth	3.74	7.60	–0.42	0.43
Labor employment	1.22	2.45	–0.70	–0.01
Capital accumulation	6.96	4.58	–0.03	0.06
Land expansion	0.00	0.00	0.00	0.00
Productivity (TFP) growth	1.96	5.65	0.02	0.37
Agglomeration	0.10	0.21	–0.06	0.00
Southern (rural) GDP growth	4.64	–0.02	–0.11	0.85
Labor employment	3.90	0.05	0.54	1.09
Capital accumulation	5.73	–0.05	–0.32	–0.18
Land expansion	2.00	0.00	0.00	0.00
Productivity (TFP) growth	0.83	–0.02	–0.12	0.73
Agglomeration	0.00	0.00	0.00	0.00
Southern (urban) GDP growth	5.82	–0.01	–0.53	0.33
Labor employment	1.92	0.01	–0.52	0.04
Capital accumulation	5.05	–0.04	–0.73	0.09
Land expansion	0.00	0.00	0.00	0.00
Productivity (TFP) growth	1.92	0.00	–0.23	0.33
Agglomeration	0.16	0.00	–0.04	0.00
Kampala (metro) GDP growth	10.44	–0.13	2.33	0.14
Labor employment	6.54	–0.16	0.89	0.17
Capital accumulation	6.45	–0.08	0.73	–0.06
Land expansion	0.00	0.00	0.00	0.00
Productivity (TFP) growth	4.27	–0.05	1.89	0.14
Agglomeration	0.52	–0.01	0.08	0.01
Net migration flows into	0.0	0.0	0.0	0.0
Northern (rural)	–5.9	–6.0	–7.5	–6.4
Northern (urban)	–0.9	0.3	–1.2	–0.9
Southern (rural)	–16.0	–15.9	–20.4	–16.9
Southern (urban)	–2.0	–2.0	–2.9	–1.9
Kampala (metro)	24.8	23.6	32.1	26.2

Source: Results from the Uganda regional computable general equilibrium model.

Faster northern growth causes a slight decline in the southern region's GDP growth rate. This is because the corridor increases relative wages in the northern region, causing a slowdown in out-migration (see Table 9). Under the baseline scenario, 892 workers (and their families) left the northern urban centers each year to work in other regions. Now, under the corridor scenario, almost 318 workers migrate to the northern urban centers each year to take advantage of the new jobs and higher wages. These migration flows may appear to be small, but this change in annual migration equals 0.55 percent of the northern urban region's total labor force.[8] Most migrants come from northern rural areas, whose workers shift their migration destination away from southern regions. As a result of fewer north-south migrants, there is a decline in the GDP growth rate in the southern regions. However, Gulu and Lira's combined workforce was less than a tenth of Kampala's in 2005, implying that the corridor's impact is small and insufficient to reverse net migration to Kampala. Furthermore, while rising urban population densities in the north generate positive agglomeration effects, these remain small compared to the direct increase in northern TFP caused by the corridor. Thus, while the corridor generates substantial growth within the northern region, the small size of this region means that national-level growth remains largely unaffected (see Table 6).

Table 10. Per capita welfare (equivalent variation) results

	Initial per capita consumption, 2005 (US$1,000)	Average annual equivalent variation growth rate, 2005–2015 (%)			
			Point deviation from baseline		
		Baseline scenario	Corridor scenario	Kampala scenario	Agriculture scenario
All households	452	4.03	0.11	1.01	1.49
Poor	163	2.15	0.32	0.65	2.06
Nonpoor	646	4.26	0.07	1.04	1.38
Rural	349	2.96	0.13	0.58	1.48
Urban	1,533	4.86	0.01	1.62	1.40
Northern	226	2.41	0.83	0.58	1.50
Rural	211	2.10	0.68	0.50	1.48
Poor	141	2.06	0.77	0.58	1.77
Nonpoor	367	2.21	0.60	0.46	1.23
Urban	669	6.39	0.59	1.77	1.72
Poor	317	4.66	0.94	1.47	2.06
Nonpoor	940	6.94	0.53	1.85	1.62
Southern	424	3.26	0.04	0.62	1.49
Rural	393	3.11	0.04	0.59	1.48
Poor	173	2.16	0.06	0.69	2.20
Nonpoor	509	3.31	0.04	0.58	1.35
Urban	1,531	5.33	0.05	1.27	1.52
Poor	238	1.90	0.04	0.65	2.27
Nonpoor	1,729	5.40	0.06	1.28	1.50
Kampala	1,638	4.57	0.06	1.79	1.36
Poor	205	1.71	0.00	0.30	2.92
Nonpoor	1,709	4.58	0.06	1.81	1.36

Source: Results from the Uganda regional computable general equilibrium model

The north-south corridor improves household welfare in the north. In this study we report welfare changes based on per capita "equivalent variation" (EV), which captures changes in household consumption spending controlling for changes in commodity prices (see Table 10). Per capita EV for northern households rises by an additional 0.8 percent per year—from 2.4 percent per year under the baseline scenario to 3.2 percent under the corridor scenario. Moreover, poor urban households benefit

[8] See Table 13.

most because the corridor creates new jobs in the less-skill-intensive manufacturing and trade sectors. Northern rural households also benefit from increased returns to nonfarm activities, but these benefits are more evenly distributed across poor and nonpoor households. This is because poor households derive more of their income from agriculture, whose productivity was unaffected by the corridor. Southern households also benefit from cheaper manufacturing goods from the north. However, this effect is small, and there are only slight improvements in household welfare at the national level.

We also report changes in the poverty headcount, which measures the share of the population living under the official poverty line (see Table 11). These poverty rates are calculated using a microsimulation module based on UNHS3. Results from the CGE model regarding each household group's changes in consumption and prices are passed down to the corresponding household in the survey (on which the model is built). Under the baseline scenario there was a significant decline in poverty, with the national headcount falling from 31.1 percent in 2005 to 24.6 percent by 2015. Under the corridor scenario there is a further decline in poverty, to 23.9 percent, due primarily to faster economic growth in the northern region and the increased participation of Uganda's poorer population in the growth process. By contrast, while southern households also benefit under this scenario, their declines in poverty are substantially smaller.

Table 11. Poverty results

	Initial value, 2005 (%)		Deviation from baseline		
		Baseline scenario	Corridor scenario	Kampala scenario	Agriculture scenario
		Final year poverty headcount, 2015 (%)			
National poverty headcount (%)	31.01	24.55	–1.36	–2.24	–6.02
Rural	34.29	27.34	–1.38	–2.54	–6.66
North	64.10	57.61	–4.65	–2.98	–9.05
South	26.84	19.78	–0.56	–2.43	–6.06
Urban	12.96	9.17	–1.27	–0.58	–2.47
North	38.81	30.77	–6.31	–1.75	–6.57
South	7.14	4.31	–0.14	–0.32	–1.55
		Final year number, 2015 (millions of people)			
Population (millions of people)	27.16	36.50	0.00	0.00	0.00
Poor population (millions of people)	8.42	8.96	–0.50	–0.82	–2.20

Source: Results from the Uganda regional computable general equilibrium model and microsimulation poverty module.

In summary, the model results indicate that investing in a north-south transport corridor reduces north-south inequality and benefits poorer urban households in the north. However, the region's small economic size prevents it from having a discernable effect on household welfare at the national level. We also find that even with increased rural-urban migration, urban agglomeration effects are small and do not significantly influence the overall impact of the corridor.

Scenario 2: Investing in Metropolitan Kampala

An alternative strategy to reducing interregional transaction costs is to focus investment in Kampala, with the intention of generating enough growth at the national level so that other regions also benefit (possibly by increasing employment opportunities for migrant workers). In the second scenario we increase economic growth in the Kampala metropolitan area. We consider the impact of increasing government spending by an additional 1.5 percent a year during 2005–2015 (i.e., about 0.25 percent of GDP or about US$25 million each year in 2005 prices). To estimate the impact of the additional spending we use a simple spending-to-TFP elasticity. Under the baseline scenario, the ratio of annual TFP growth (1.6 percent) to annual government spending growth (6.0 percent) was about 0.2. We apply this elasticity of 0.2 to the new government spending to arrive at an *exogenous* TFP increase for Kampala's

nonagricultural sectors of 1.5 percent each year (weighted by Kampala's contribution to national GDP). Table 6 shows the additional government spending growth rate (from 6.0 to 7.5 percent per year) and the increase in the TFP growth rate (from 1.64 to 2.00 percent). Together these generate an additional spending-to-TFP elasticity of 0.24, which is slightly higher than the exogenous 0.2 elasticity as a result of endogenous agglomeration economies for Kampala industries.[9] To ensure comparable financing mechanisms we assume that Uganda's government borrows from domestic financial markets, thus increasing the fiscal deficit and crowding out private investment (see Table 6).[10] By using the same financing mechanism, we can focus on the distributional impacts of alternative growth and investment strategies rather than the joint impact of alternative financing mechanisms.[11]

Faster TFP growth in Kampala raises the region's GDP growth rate by an additional 2.3 percent a year during 2005–2015—from 10.4 to 12.7 percent per year (see Table 8). Since we assume that all sectors, with the exception of the government, benefit from faster productivity growth, the additional growth is fairly balanced across sectors. Furthermore, since Kampala is a significant part of Uganda's economy, its expansion increases national GDP growth by an additional 0.7 percent each year (see Table 6).

Accelerated economic growth increases demand for labor in the capital city, which increases wages relative to the rest of the country and causes the number of migrants coming to Kampala to increase (see Table 9). Thus, while 24,800 workers migrated each year to the capital under the baseline scenario, there are 32,100 migrants under the Kampala scenario. These new migrants come primarily from rural areas in both the northern and southern regions. Again the change may appear small, but these additional 7,300 migrants arriving in the capital city each year accumulate, accounting for 7.9 percent of Kampala's workforce by 2015. This contributes to the rising population density of Kampala, which has positive, albeit small, agglomeration gains.

Increased migration to the capital city reduces the supply of skilled labor in other regions, causing their GDP growth rates to decline (see Table 8). The worst affected sectors are those producing goods that compete with Kampala's producers, such as manufacturing. Regional trade services also decline because a larger share of traded goods now originates within Kampala, which benefits the capital city's trade and transport sector. Faster economic growth in Kampala therefore reduces growth in other regions because of increased migration, regional trade competition, and to a lesser extent, negative agglomeration effects.

However, slower GDP growth in rural areas and smaller urban centers does not lead to declining per capita welfare under the Kampala scenario. Slower economic growth is partly offset by the out-migration of workers and their families, which contributes to rising per capita expenditures for the households that remain behind (see Table 10). More important, however, faster growth in Kampala raises demand for goods produced in other regions, such as food and agriculture, whose prices rise relative to the baseline scenario (see Table 6). Agricultural growth accelerates, causing real incomes to rise in rural

[9] Spending-to-TFP elasticities are likely to vary with the sector of investment and with the levels of investment in the target and other sectors (i.e., diminishing returns and investment interactions). To ensure comparability between scenarios we do not take either of these factors into account in our analysis (i.e., our elasticity remains constant over time and does not vary between investment simulation).

[10] Although the different scenarios use the same spending-to-TFP elasticity, it is difficult to design comparable financing mechanisms. For instance, the transport corridor might require more foreign borrowing (development assistance), which would defer actual payments for the investment. By contrast, accelerating growth in Kampala might require new policies to improve the business environment, with more immediate recurrent cost to the government. Furthermore, the transport corridor might cost more in the short term but generate longer-term benefits, whereas growth effects from trade reforms might have a shorter time frame but a smaller cost.

[11] Using the same spending-to-TFP elasticity (0.2), the cost of the north-south corridor to the government would be only a tenth of the cost of the Kampala scenario (i.e., the government spending growth rate rises by 0.15 percent). This is because the northern urban economy is much smaller than Kampala's, making its impact on national TFP growth substantially smaller. The annual increase in government spending is US$2.5 million each year (in 2005 prices), implying that the total cost of the corridor over 10 years is US$25 million. We do not model a lag between investment and productivity gains (i.e., overstating immediate gains). We do not capture returns beyond 2015 (i.e., understating long-term gains). Finally, we assume that maintenance costs are included within the annual cost of the corridor's development (i.e., overstating actual investment spending and hence productivity gains).

areas. Finally, increased production in Kampala lowers the price of manufactured goods, which benefits consumers in other regions, especially urban households that spend a larger share of their incomes on manufactured goods.

Ultimately, however, most of the benefits of this strategy accrue to households within Kampala (see Table 10). Only a small share of these households falls below the poverty line, since most of Uganda's poor population lives in rural areas and the northern region. Thus, while per capita EV among Uganda's poor households rises by an additional 0.65 percent each year, it rises by 1.04 percent for nonpoor households. This means that concentrating growth in Kampala worsens inequality at the national level. It does, however, reduce national poverty more than does the corridor scenario (see Table 11), although the two scenarios are not strictly comparable due to differences in the magnitude of government spending (see Table 6).

In summary, the model results indicate that a growth strategy focused on Kampala benefits households outside of the capital city. However, while the Kampala scenario creates jobs for new migrants, its impact on national incomes remains relatively small. For example, the 7,300 additional migrant workers in the capital city under this scenario would constitute 8 percent of Kampala's workforce, but they would represent only 0.7 percent of Uganda's total workforce by 2015. Furthermore, while these workers and their families increase Kampala's population density, their positive agglomeration effects contribute little to economic growth both in the city and in the country as a whole. Therefore, a Kampala-driven growth strategy is effective at stimulating national economic growth and improving incomes, but it widens the divide between poor and nonpoor Ugandans, especially in rural areas and in the north of the country.

Scenario 3: Improving Agricultural Productivity in Rural Areas

The third strategy that we consider is investing in agricultural productivity, which is much lower in the north than in the south. For instance, average crop yields for most major crops are typically much lower in the north (see Table 12). Improving farm technologies is a key policy objective of Uganda's government. For example, the government is revising its National Development Plan, with agriculture playing an important role in the country's future growth strategy. In the agriculture scenario we increase TFP growth rates in the agricultural sector in both the northern and southern regions. As with the Kampala scenario, we model an increase in government recurrent spending by 1.5 percent per year (or about US$25 million each year in 2005 prices). Using the spending-to-TFP elasticity of 0.2 and weighting for agriculture's contribution to national GDP, we increase agriculture's TFP growth rate by an additional 1.5 percent (see Table 4). Model results for the agriculture scenario indicate that this simulation is roughly equivalent to Uganda's moving a third of the way toward achieving the targets identified under the Comprehensive African Agricultural Development Program (CAADP) process (see Thurlow et al. 2008).[12] As such, the agriculture scenario considers relatively modest gains in productivity. Moreover, the target yields for major northern crops, such as maize and millet, are below those achieved in other low-income African countries.[13] Finally, as with the previous scenario, we increase government spending, thereby expanding the fiscal deficit and crowding out private investment. Thus, because the exogenous TFP impacts are of similar magnitude and we employ the same financing mechanism, it is possible to directly compare the results from the Kampala and agriculture scenarios.

[12] CAADP is an initiative of the New Economic Partnership for African Development. Under this compact, African governments are committing themselves to allocating 10 percent of their budgets to the agricultural sector for these countries to achieve 6 percent annual agricultural growth by 2015.

[13] For example, the modeled northern maize yield of 1.36 mt/ha in 2015 is below the 2006 yield in 26 out of 50 African maize-producing countries, including Kenya (1.72), Mali (1.50), Senegal (1.39) and Tanzania (1.69). Similarly, the northern millet yield target of 1.06 mt/ha is below the 2006 yield of 9 out of 36 African millet-producing countries, including Ethiopia (1.28) and Burundi (1.17).

Table 12. Agricultural production targets and results

	Initial yields in 2005 (tons/hectare)			Final year yields, 2015 (tons/hectare)		
	Southern (rural)	Northern (rural)	Uganda average	Baseline scenario	Agriculture scenario	CAADP target
Cereals						
Maize	1.75	1.11	1.65	1.86	2.07	2.34
Rice	1.57	0.65	1.45	1.85	2.08	2.00
Other cereals	1.98	0.89	1.50	1.69	1.83	1.96
Root crops						
Cassava	7.07	5.29	6.70	7.63	8.69	9.99
Irish potatoes	6.97	4.07	6.94	7.89	9.04	9.95
Sweet potatoes	4.38	4.66	4.40	5.02	5.72	6.53
Horticulture						
Vegetables	6.07	4.90	5.99	6.79	7.92	9.24
Fruits	4.74	2.17	4.66	5.28	6.08	6.78
Pulses and oil seeds						
Oil seed crops	0.98	0.33	0.60	0.67	0.78	0.90
Beans	0.82	0.36	0.73	0.83	0.93	1.03
Matoke	5.77	1.90	5.76	6.63	7.76	9.03
Export crops						
Cotton	0.29	0.92	0.48	0.62	0.70	0.74
Tobacco	0.76	0.49	0.62	0.56	0.69	0.99
Coffee	0.65	0.65	0.65	0.62	0.78	1.09
Tea	9.00		9.00	10.03	10.41	10.58
Other crops	13.32	8.81	12.00	12.84	14.22	16.46

Source: Yields and CAADP targets from 2005/06 Uganda National Household Survey (UBOS, 2006) and Thurlow et al. (2008). Results from the Uganda regional computable general equilibrium model.
Note: CAADP is the Comprehensive African Agricultural Development Program.

Raising agricultural productivity and crops yields causes the agricultural sector to grow by an additional 1.3 percent each year (see Table 5). Agriculture's GDP growth rate increases from 3.4 percent per year under the baseline scenario to 4.7 percent under the agriculture scenario.[14] While all agricultural subsectors benefit from faster growth, including livestock, forestry, and fisheries, it is the export crops that grow most rapidly. This is because food crops face more stringent market or demand constraints, which cause agricultural prices to decline when production expands. The real food price index therefore falls relative to the baseline scenario (see Table 6). This reduces the incentive for farmers to expand production and increases the incentive to diversify into other crops where price declines are less severe. By contrast, agricultural export crops are more reliant on foreign markets, where demand constraints are typically less binding.[15] Agricultural exports therefore expand more rapidly than other crops under the agriculture scenario.

Since agriculture is a large part of Uganda's economy, its faster growth rate causes national GDP to grow by an additional 0.6 percent per year (see Table 8). Not surprisingly, most of this growth occurs in the two rural regions, especially in the northern rural region, where agriculture is a particularly important sector (see Table 2). Urban regions also benefit, however, from faster agricultural growth, which provides inputs into the food and agricultural export processing sectors located in these centers. Nonagricultural growth is further stimulated by higher rural incomes, which generate demand for manufactured goods. Rural households also respond to higher agricultural productivity by diversifying

[14] Approximately half-way to achieving the CAADP six percent agricultural growth rate target.

[15] We assume that Uganda, as a small country, faces unconstrained foreign demand at fixed world prices (relative to the baseline scenario). This assumption applies to all internationally traded commodities.

their incomes into nonfarm activities. Moreover, rural households typically spend more of their incomes on goods and services produced locally than do urban households. Thus, even though nonagricultural imports grow faster under the agriculture scenario, the increase is substantially smaller than under the Kampala scenario (see Table 6). Ultimately, however, the agriculture scenario generates slightly less additional economic growth at the national level than the Kampala scenario. This is because rural growth does not crowd in as much private investment as urban industrial growth under the Kampala scenario. Nor does agricultural growth increase exports by as much (i.e., production shifts toward food crops and livestock, which are less export intensive than many of the industrial sectors—see Table 1).

Faster economic growth in rural areas increases migration to urban areas (see Table 9). The number of rural-to-urban migrants each year rises from 24,800 under the baseline scenario to 26,200 under the agriculture scenario. Increasing agricultural workers' productivity reduces the labor constraint in rural areas, thus allowing greater migration to urban centers while also encouraging greater diversification into rural nonfarm employment. The rural nonfarm economy therefore expands under this scenario, with the rural manufacturing sectors growing by an additional 1.3 percent each year (see Table 8). However, releasing agricultural labor, higher agricultural productivity slightly widens the rural-urban wage differential (see Table 13). Moreover, the rural-urban wage differential also widens because of rising urban wages caused by agricultural growth, stimulating growth in urban centers through increased demand for industrial products and services. Faster agricultural growth does, however, narrow the north-south wage ratio, due in part to the northern region's greater dependence on the agricultural sector. This effect remains small since we are increasing agricultural productivity in rural areas in both the northern and the southern regions.

Table 13. Wage differentials and migration rate results

	Initial, 2005	Baseline scenario	Corridor Scenario	Kampala scenario	Agriculture scenario
		Final ratio in 2015			
Rural-urban wage ratio	0.253	0.246	0.245	0.233	0.230
Skilled labor	0.705	0.742	0.743	0.742	0.749
Semiskilled labor	0.495	0.494	0.495	0.478	0.493
Unskilled labor	0.193	0.196	0.195	0.181	0.188
North-south wage ratio	0.753	0.745	0.764	0.749	0.753
Skilled labor	0.973	0.988	1.013	0.988	0.984
Semiskilled labor	0.817	0.825	0.876	0.831	0.816
Unskilled labor	0.851	0.847	0.873	0.851	0.854
Annual in-migration rate (%)					
Northern (rural)	—	–0.28	–0.27	–0.34	–0.28
Northern (urban)	—	–1.87	0.55	–2.65	–1.89
Southern (rural)	—	–0.24	–0.23	–0.29	–0.23
Southern (urban)	—	–1.08	–1.07	–1.61	–1.04
Kampala (metro)	—	2.90	2.80	3.51	3.02

Source: Results from the Uganda regional computable general equilibrium model.
Note: South wage includes Kampala. In-migration rate is average number of net migrants entering a region each year as a share of that region's total labor force.

Even though national growth does not increase by as much under the agriculture scenario, there is a larger increase in rural per capita consumption spending compared to the Kampala scenario (see Table 6). This is because a larger share of the returns to agricultural growth accrues to poorer and rural households, both of which devote a larger share of their incomes to consumption. Rural and poor

households are therefore the main beneficiaries of agricultural growth, and their per capita EV rises by an additional 1.5 and 2.1 percent, respectively (see Table 10). Urban households also benefit from cheaper food prices and nonagricultural employment opportunities in the processing and service sectors. This is especially true in the northern region, where the benefits from agricultural growth exceed those in the south and are more evenly distributed across rural and urban households.

Increasing agricultural growth also causes a large decline in national poverty, despite having a smaller effect on national growth (see Table 11). This is because a majority of Uganda's poor population live in rural areas where they rely heavily on agricultural incomes. Poverty falls by an additional 6 percent compared to the baseline scenario. This means that accelerating agricultural growth lifts an additional 2.2 million people above the poverty line compared to the baseline scenario and an additional 1.4 million people compared to the Kampala scenario.

Not only do the agriculture and Kampala scenarios differ in their impacts on per capita welfare at the national level; their distributional implications are also quite different. Kampala growth favors households within the capital city and, to a far lesser extent, households in rural areas. Its main beneficiaries are therefore nonpoor households, leading to a widening rural-urban and north-south divide (see Table 13). Surprisingly, even though investment under the corridor scenario is one-tenth the size of that under the Kampala scenario, the corridor scenario produces half of the benefits for poor households compared with those achieved under the Kampala scenario and, less surprisingly, larger impacts on northern households. By contrast, the agriculture scenario leads to broad-based welfare improvements across the five regions, including benefits for Kampala households. Agricultural growth is also more propoor, with substantially larger welfare improvements for poor households.

5. CONCLUSIONS

Uganda's economy has grown rapidly during the past decade, leading to large reductions in poverty. However, this growth process has been fairly uneven, with agricultural growth remaining sluggish. Growth has also become increasingly concentrated within the country's capital city and major urban centers in the south. The northern region has, by contrast, continued to lag behind national development, with poverty remaining largely unchanged since the early 1990s. This is a significant constraint to further development, not least because a fifth of the country's population and two-fifths of its poor population live in the north.

The baseline scenario of the CGE model simulations, which represents a continuation of the productivity gains of the past decade, suggests that high GDP growth (6 percent per year), largely concentrated in the south, would result in rapid overall annual per capita consumption growth (4.0 percent) but a widening regional gap as Kampala consumption rises by 4.6 percent per year while per capita consumption in the north grows by only 2.4 percent per year. Poverty rates in the north would decline by 6.5 percent—in the rural north to 57.6 percent—but this would still dwarf poverty rates in the rural south (19.8 percent) and the urban south (4.3 percent).

Simulations of the impact of reducing transaction costs between the northern and southern urban centers indicate that this policy has only modest effects on regional growth and poverty reduction, reflecting the smaller size of the overall investment. Improvements in the north-south transport corridor benefit northern households, but the effects are limited by the small size of the northern urban centers, which currently contain less than 1 percent of Uganda's population. Thus rapid growth in Gulu and Lira has little effect at the national level. The benefits of the corridor are further constrained by the low productivity of northern agricultural producers, who make up most of the region's population. Thus, the positive effects of improving north-south trade linkages are constrained by the northern region's capacity to take advantage of new market opportunities.

Accelerating growth in Kampala, even beyond its high growth rates over the past decade, does not generate sufficient economywide growth linkages to substantially improve conditions in rural areas and other urban centers. The simulations suggest that rapid growth in Kampala is insufficient to create enough new jobs for rural-urban migration to have a discernable impact on national poverty reduction over the coming decade. Moreover, and not surprisingly, a Kampala-driven growth strategy widens the north-south divide. Even after taking regional growth linkages and migration opportunities into account, the northern region still remains largely isolated from the national growth process.

A third alternative growth strategy, improving agricultural productivity in rural areas, has a much more positive impact on growth and poverty reduction in northern Uganda, a region where current crop yields are far below potential yields. Model results indicate that raising agricultural productivity may, however, be less effective than urban development in generating growth at the national level. Yet agricultural growth stimulates urban development by creating additional demand for urban products, reducing food prices for urban consumers, and thereby increasing rural-urban migration. It leads to significant and broad-based welfare improvements, especially among the urban poor and rural households in the north of the country. Moreover, in our analysis we consider relatively modest gains in productivity. We modeled a 15 percent increase in crop yields, which is below the 40 percent increase targeted under Uganda's CAADP. The yields that we target for the major northern crops, such as maize and millet, are still below those achieved in many other low-income African countries. However, demand constraints for agricultural products, especially food crops, highlight the need to improve both productivity and market opportunities for rural producers.

Overall, the results indicate that if Uganda continues on its current growth path of Kampala-centered growth, regional inequality will worsen and poverty rates will remain very high in the northern region. This adverse outcome results in spite of an assumption that increased urbanization leads to major gains in total factor productivity gains from agglomeration effects. Only with rapid productivity growth in agriculture is the income gap between north and south substantially narrowed and overall poverty rates in

the north reduced. Thus, despite positive agglomeration effects from urban growth, accelerating agricultural growth should remain a key component of any growth strategy aimed at substantially reducing between-regions income inequalities and overall poverty in Uganda.

APPENDIX A: THE REGIONAL SOCIAL ACCOUNTING MATRIX

Table A.1. Agricultural commodities and nonagricultural sectors in the Uganda model

Agricultural subsectors	
	Cereals
1	Maize
2	Rice
3	Other cereals (including millet, sorghum)
	Root crops
4	Cassava
5	Irish potatoes
6	Sweet potatoes
	Horticulture
7	Vegetables
8	Fruits (including passion fruits, other tree crops, sweet bananas)
	Pulses and oil seeds
9	Oil seed crops (including simsim, sunflower seeds, groundnuts)
10	Beans (including cowpeas, soybeans)
11	Matoke (plantains or food bananas)
	High-value export-oriented crops
12	Cotton
13	Tobacco
14	Coffee
15	Tea leaves
16	Other export crops (including sesame)
	Livestock
17	Cattle
18	Poultry
19	Other livestock (including sheep, goats, pigs)
20	Forestry
21	Fisheries
Industrial subsectors	
22	Mining
23	Meat processing
24	Fish processing
25	Food processing
26	Grain milling
27	Animal feed processing
28	Beverages and tobacco
29	Textiles and clothing
30	Wood and paper products
31	Fuels
32	Chemicals
33	Fertilizer
34	Other manufacturing
35	Machinery and equipment
36	Furniture
37	Utilities
38	Construction
Service subsectors	
39	Trade services
40	Hotels and catering
41	Transport services
42	Communication services
43	Financial and banking services
44	Real estate
45	Other private services
46	Government services
47	Community services

APPENDIX B: SPECIFICATION OF THE REGIONAL COMPUTABLE GENERAL EQUILIBRIUM MODEL

Table B.1. Model sets, parameters, and variables

Sets		Sets	
a	Activities	$h \subset i$	Households
c	Commodities	r	Foreign trading regions
f	Factors	t	Time periods
i	Institutions (+ rest of world)		
Latin parameters		**Greek parameters**	
$cwts_c$	Weight in consumer price index	α_a^{va}	Production efficiency parameter
$dwts_c$	Weight in domestic price index	α_c^{ac}	Aggregation shift parameter
ica_{ca}	Intermediate input per output unit	α_c^{q}	Armington function shift parameter
$icd_{cc'}$	Trade input per unit produced and sold domestically	α_c^{t}	Export function shift parameter
$ice_{cc'}$	Trade input per exported unit	β^a	Capital sectoral mobility factor
$icm_{cc'}$	Trade input per imported unit	β_{ch}^m	Marginal budget share
$inta_a$	Aggregate intermediate input	δ_a^a	Activity function share parameter
iva_a	Aggregate factor input	δ_{ac}^{ac}	Aggregation share parameter
$\overline{mps_i}$	Domestic savings rates	δ_{cr}^{q}	Armington function share parameter
pwe_c	Export price (foreign currency)	δ_{cr}^{t}	Export function share parameter
pwm_c	Import price (foreign currency)	δ_{fa}^{va}	Production function share parameter
$qdst_c$	Stock change quantity	γ_{ch}^{m}	Household subsistence consumption
$\overline{qg_c}$	Base-year government demand	θ_{ac}	Yield of output per unit of output
$\overline{qinv_c}$	Base-year private investment	ρ_a^a	Production function exponent
$shif_{if}$	Institutions' share of factor income	ρ_a^{va}	Value-added function exponent
$shii_{ii'}$	Net factor incomes transferred	ρ_c^{ac}	Aggregation function exponent
$\overline{tins_i}$	Direct tax rates	ρ_c^{q}	Armington function exponent
tm_c	Import tariff rate	ρ_c^{t}	Export function exponent
tq_c	Sales tax rate	η_{fat}^{a}	Sector share of new capital
$trnsfr_{i\,f}$	Factor transfer to institution	υ_f	Capital depreciation rate
pop_h	Household population	τ	Migration-rate/wage-rate elasticity
qfs_f	Quantity of factor supply	κ	Agglomeration effect elasticity
$m_{ff't}^0$	Base-year migration rate	ε_f	Labor-supply to wage-rate elasticity
wf_f^0	Base-year wage rate		

Table B.1. Continued

Variables			
AWF_{ft}^{a}	Average capital rental rate	QA_a	Quantity (level) of activity
$\overline{CPI}$	Consumer price index	QD_c	Quantity sold domestically of domestic output
DPI	Domestic price index	QE_{cr}	Export demand quantity
EG	Government expenditures	QF_{fa}	Activity factor demand
EH_h	Demand spending for household	QG_c	Government demand quantity
EXR	Exchange rate	QH_{ch}	Demand quantity for households
$\overline{FSAV}$	Foreign savings in foreign	$QINTA_a$	Aggregate intermediate input
$\overline{GADJ}$	Government demand adjustment	$QINT_{ca}$	Input technical coefficients
$GSAV$	Government savings	$QINV_c$	Investment demand quantity
$\overline{IADJ}$	Investment adjustment factor	QM_{cr}	Import supply quantity
K_{fat}^{a}	Activity's quantity of new capital	QQ_c	Goods supplied to domestic market (composite supply)
$M_{ff'}$	Migration rate from f to f'	QT_c	Quantity of commodity demanded as trade input
PA_a	Activity price (unit gross revenue)	QVA_a	Quantity of (aggregate) value added
PDD_c	Demand price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PDS_c	Supply price for commodity produced and sold domestically	$QXAC_{ac}$	Quantity of output of commodity c from activity a
PE_{cr}	Export price (domestic currency)	$TRII_{ii'}$	Transfers from institution i' to i
$PINTA_a$	Aggregate intermediate input price for activity a	WF_f	Average price of factor
PK_{ft}	Unit price of capital in time period t	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
PM_{cr}	Import price (domestic currency)	YF_f	Income of factor f
PQ_c	Composite commodity price	YG	Government revenue
PVA_a	Value-added price (factor income per unit of activity)	YI_i	Income of domestic nongovernment institution
PX_c	Aggregate producer price for commodity	YIF_{if}	Income to domestic institution i from factor f
$PXAC_{ac}$	Producer price of commodity c for activity a		

Table B.2. Model equations

Within-period production and price equations

$$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c'} PQ_c \cdot ice_{c'c} \quad (1)$$

$$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c'} PQ_{c'} \cdot icm_{c'c} \quad (2)$$

$$PA_a \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad (3)$$

$$PA_a = \sum_c PXAC_{ac} \cdot \theta_{ac} \quad (4)$$

$$PINTA_a = \sum_c PQ_c \cdot ica_{ca} \quad (5)$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr} \quad (6)$$

$$PDD_c = PDS_c + \sum_{c'} PQ_{c'} \cdot icd_{c'c} \quad (7)$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr} \quad (8)$$

$$CPI = \sum_c PQ_c \cdot cwts_c \quad (9)$$

$$DPI = \sum_c PDS_c \cdot dwts_c \quad (10)$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (11)$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}-1} \quad (12)$$

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \quad (13)$$

$$QVA_a = iva_a \cdot QA_a \quad (14)$$

$$QINTA_a = inta_a \cdot QA_a \quad (15)$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad (16)$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_a \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}} \quad (17)$$

$$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_a \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1} \quad (18)$$

$$QX_c = QD_c + \sum_r QE_{cr} \quad \text{if commodity not exported or not supplied domestically} \quad (19)$$

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad \text{if exported and domestically supplied} \quad (20)$$

Table B.2. Continued

Within-period production and price equations(continued)

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad \text{if exported and domestically supplied} \tag{21}$$

$$QQ_c = QD_c + \sum_r QM_{cr} \quad \text{if commodity not imported or not supplied domestically} \tag{22}$$

$$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \quad \text{if imported and domestically supplied} \tag{23}$$

$$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}} \quad \text{if imported and domestically supplied} \tag{24}$$

Within-period institutional incomes and domestic demand equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \tag{25}$$

$$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right] \tag{26}$$

$$YI_i = \sum_f YIF_{if} + \sum_{i'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR \tag{27}$$

$$TRII_{ii'} = shii_{ii'} \cdot (1 - \overline{mps}_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \tag{28}$$

$$EH_h = \left(1 - \sum_i shii_{ih} \right) \cdot \left(1 - \overline{mps}_h \right) \cdot (1 - \overline{tins}_h) \cdot YI_h \tag{29}$$

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c'} PQ_{c'} \cdot \gamma_{c'h}^m \right) \tag{30}$$

$$QINV_c = IADJ \cdot \overline{qinv}_c \tag{31}$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \tag{32}$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_i trnsfr_{i\,gov} \cdot \overline{CPI} \tag{33}$$

Within-period system constraints and macroeconomic closures

$$YG = \sum_i \overline{tins}_i \cdot YI_i + \sum_c tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_c tq_c \cdot PQ_c \cdot QQ_c + trnsfr_{gov\,row} \cdot EXR \tag{34}$$

$$QQ_c = \sum_a QINT_{ca} + \sum_h QH_{ch} + QG_c + QINV_c + qdst_c + QT_c \tag{35}$$

$$\sum_a QF_{fa} = \left(qfs_f \right) \cdot \left(WF_f / wf_f^0 \right)^{\varepsilon_f} \quad \text{for unskilled rural labor} \tag{36}$$

$$\sum_a QF_{fa} = qfs_f \quad \text{for all other labor categories} \tag{37}$$

$$YG = EG + GSAV \tag{38}$$

Table B.2 Continued

Within-period system constraints and macroeconomic closures (continued)	
$\sum_{r\,c} pwm_{cr} \cdot QM_{cr} + \sum_{f} trnsfr_{row\ f} = \sum_{r\,c} pwe_{cr} \cdot QE_{cr} + \sum_{i} trnsfr_{i\,row} + FSAV$	(39)
$\sum_{i} \overline{mps}_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c} PQ_c \cdot QINV_c + \sum_{cC} PQ_c \cdot qdst_c$	(40)
Between-periods migration and population, labor supply, and productivity growth (agglomeration)	
$M_{ff't} = m^0_{ff't} \cdot \left[\left(\frac{WF_{f't}}{wf^0_{f'}} \right) \Big/ \left(\frac{WF_{ft}}{wf^0_{f}} \right) \right]^{\tau}$	(41)
$qfs_{ft} = qfs_{ft-1} \cdot \left(1 + lfsgr_f\right) + \sum_{f'} \left(qfs_f \cdot M_{f'ft} - qfs_{f'} \cdot M_{ff't} \right)$	(42)
$pop_{ht} = pop_{ht-1} \cdot \left[\left(\sum_{f} shif_{hf} \cdot qfs_{ft} \right) \Big/ \left(\sum_{f} shif_{hf} \cdot qfs_{ft-1} \right) \right]$	(43)
$\gamma^m_{cht} = \gamma^m_{cht-1} \cdot \left(pop_{ht} / pop_{ht-1} \right)$	(44)
$\alpha^{va}_{at} = \alpha^{va}_{at-1} \cdot \left(1 + tfpgr_a\right) \cdot \left(\sum_{fa'} QF_{fa't} \Big/ \sum_{fa'} QF_{fa't-1} \right)^{\kappa}$ if a and a' are in the same region	(45)
Between-periods capital accumulation and allocation equations	
$AWF^a_{f\,t} = \sum_{a} \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right]$	(46)
$\eta^a_{f\,a\,t} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF^a_{f\,t}} - 1 \right) + 1 \right)$	(47)
$\Delta K^a_{f\,a\,t} = \eta^a_{f\,a\,t} \cdot \left(\frac{\sum_{c} PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right)$	(48)
$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}}$	(49)
$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^a_{f\,a\,t}}{QF_{f\,a\,t}} - \upsilon_f \right)$	(50)
$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right)$	(51)

APPENDIX C: SENSITIVITY ANALYSIS ON KEY MODEL PARAMETERS

We conduct sensitivity around two of the model's key parameters that were not estimated econometrically. First, we double the size of agglomeration effects (κ in equation 45 in Appendix B) and rerun the Kampala scenario, which is most sensitive to urban-based agglomeration. Second, we halve and double the labor supply elasticity (ε in equation 36) for rural unskilled labor and rerun the agriculture scenario, which is the one most affected by this adjustment. The main results are shown in Table C.1.

Increasing the agglomeration parameter raises Kampala's growth rate relative to the original Kampala scenario (i.e., from 12.8 to 13.9 percent per year). This growth increases the rate of migration to the capital city, causing a slightly larger decline in economic growth in other regions. Accordingly, national economic growth increases only slightly. Private services and manufacturing are the main beneficiaries of larger agglomeration effects since these sectors are concentrated in urban centers, but agricultural growth increases only slightly due to higher demand for agricultural products from urban centers. Thus, while larger agglomeration effects increase the contribution of Kampala-driven growth to national economic growth, they have a relatively smaller impact on the incomes of poor and rural households, especially in the northern regions. The conclusions we reach, that Kampala-driven growth benefits national economic growth but has a smaller impact on national poverty reduction, is therefore robust to changes in the agglomeration parameter.

Increasing or decreasing rural unskilled labor supply elasticities makes the rural economy more or less flexible to changes in agricultural productivity. For instance, increasing the supply elasticity increases labor employment growth from 5.0 percent under the agriculture scenario to 6.4 percent under this scenario. This additional supply of productive resources raises agricultural growth and, through forward production and backward rural demand linkages, fosters additional rural nonfarm production (as seen by the higher manufacturing and private services growth rates). The northern and southern rural regions are the main beneficiaries, but linkage effects also foster additional growth in the urban regions, including Kampala. Thus, rural incomes and poverty are most affected by changes to labor supply elasticities. However, the benefits to agricultural growth still accrue to both rural and urban households, especially in northern regions, thus confirming the conclusions drawn from the agriculture scenario.

Table C.1. Sensitivity analysis

	Average annual growth rate, 2005–2015 (%)				
	Kampala scenario $\kappa = 0.08$	High agglomeration $\kappa = 0.16$	Agriculture scenario $\varepsilon = 2.0$	Low supply elasticity $\varepsilon = 0.5$	High supply elasticity $\varepsilon = 4.0$
Gross domestic product	6.77	7.15	6.71	6.39	7.02
Agriculture	3.57	3.65	4.69	4.30	5.08
Manufacturing	8.84	9.46	8.24	7.85	8.63
Other industry	7.39	7.78	6.95	6.61	7.29
Private services	8.36	8.97	7.72	7.38	8.05
Public services	7.19	7.25	7.21	7.15	7.27
Northern (rural)	3.11	3.05	4.21	3.73	4.68
Northern (urban)	3.32	3.12	4.16	3.97	4.34
Southern (rural)	4.53	4.50	5.49	5.17	5.82
Southern (urban)	5.29	5.18	6.15	5.98	6.32
Kampala (metro)	12.77	13.88	10.58	10.29	10.86
Consumption	6.16	6.47	6.38	6.06	6.71
Investment	7.13	7.44	6.75	6.42	7.09
Government	7.50	7.50	7.50	7.50	7.50
Exports	7.79	8.51	7.25	6.75	7.74

Table C.1. Continued

	Average annual growth rate, 2005–2015 (%)				
	Kampala scenario $\kappa = 0.08$	High agglomeration $\kappa = 0.16$	Agriculture scenario $\varepsilon = 2.0$	Low supply elasticity $\varepsilon = 0.5$	High supply elasticity $\varepsilon = 4.0$
Imports	7.16	7.56	6.86	6.59	7.13
Labor	4.61	4.78	5.02	3.59	6.38
Capital	5.91	6.02	5.79	5.68	5.90
Land	2.00	2.00	2.00	2.00	2.00
Productivity (TFP)	2.01	2.37	1.95	2.23	1.65
Per capita equivalent variation	5.03	5.55	5.52	4.96	6.08
Poor	2.80	3.09	4.22	3.16	5.33
Nonpoor	5.30	5.85	5.65	5.19	6.12
Rural	3.54	3.83	4.45	3.89	5.03
Urban	6.48	7.33	6.26	5.83	6.68
Northern	2.99	3.28	3.91	3.25	4.59
Southern	3.88	4.19	4.75	4.23	5.30
Kampala	6.36	7.34	5.93	5.47	6.37

Source: Results from the Uganda regional computable general equilibrium model.

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